CLAIMS

1. An optical phase detector (30) comprising;

means (2) for receiving two optical inputs (3,4) and producing two combined optical outputs (11,12),

detection means (32) for detecting the intensity of the two combined optical outputs and converting the intensity of each of the combined optical outputs (11,12) into an electrical signal, and

means (6) for measuring the difference between the two electrical signals and generating an output difference signal (20),

a voltage-controlled electro-optic phase modulator (35) for modulating the phase of one optical input to the optical phase detector,

characterised in that the electro-optic phase modulator has a substantially linear response and whereby, in use, the output difference signal (20) is maintained at a substantially constant level by varying the voltage (36) applied to the electro-optic phase modulator (35), the voltage being applied to the electro-optic phase modulator by means of a feedback loop in response to the output difference signal (20) and the applied voltage providing an indication of the phase difference between the two optical inputs (3,4).

2. The optical phase detector of claim 1 wherein the frequency response of the electro-optic phase modulator (35) is at least 1 MHz.

3. The optical phase detector of claim 2 wherein the frequency response of the electro-optic phase modulator (35) is at least 1 GHz.

4. The optical phase detector of any of claims 1 to 3, including coupling means (2) for receiving the two optical inputs (3,4) and producing the two combined optical outputs (11,12).

5. The optical phase detector of claim 4, wherein the coupling means (2) produce two intermediate optical outputs from each of the optical inputs (3,4), the two intermediate optical outputs produced from each of the optical inputs being in phase quadrature, and

wherein the intermediate optical outputs are combined to form the two optical outputs (11,12).

6. The optical phase detector of any of claims 1-5, and further comprising means (44, 46) for feeding back the output difference signal to the electro-optic phase modulator (35), the applied voltage to the electro-optic modulator being varied in response to the output difference signal so as to maintain the difference signal at the substantially constant level.

7. The optical phase detector of claim 6, wherein the substantially constant level is zero volts.

8. The optical phase detector of any of claims 1-7, wherein the electro-optic phase modulator (35) comprises an optical waveguide on an integrated optic substrate.

9. The optical phase detector of claim 8 wherein the substrate is any of lithium niobate, lithium tantalate or gallium arsenide.

10. The optical phase detector of any of claims 1-7, wherein the electro-optic phase modulator (35) takes the form of an optical fibre carrying a piezoelectric material.

11. The optical phase detector of any of claims 1-10, whereby, in use, the optical inputs (3,4) supplied to the optical phase detector have substantially equal amplitudes.

12. The optical phase detector of any of claims 1-11 whereby, in use, the optical inputs (3,4) supplied to the optical phase detector are obtained from the same source of radiation.

13. The optical phase detector of any of claims 1-11 wherein the optical inputs (3,4) are obtained from different sources of radiation.

14. The optical phase detector of any of claims 1-13, comprising an optical fibre coupler (2) for receiving the two optical inputs (3,4).

15. The optical phase detector of any of claims 1-14, and further comprising polarisation modulation means for modulating the polarisation of at least one of the inputs to the optical phase detector so as to ensure the polarisation of the two inputs is substantially the same.

16. The optical phase detector of claim 15, wherein the polarisation modulation means is any one of a fibre-optic polarisation modulator or an integrated optic polarisation modulator.

17. The optical phase detector of any of claims 1-16, comprising two photodetectors (5a,5b), each one for detecting the intensity of one of the two optical outputs (11,12) and for generating an electrical output signal (7a,7b) in response to the corresponding optical output (11,12).

18. The optical phase detector of claim 17 wherein the photodetectors (5a,5b) are matched.

19. A frequency discriminator apparatus (60) comprising the optical phase detector (30) of any of claims 1-18 and further comprising;

input means (41) for receiving a primary optical input (42) from a source of radiation (43) having a frequency, and for producing two primary optical outputs (52, 53),

means (50,51) for introducing a relative delay between the two primary optical outputs (52, 53),

the two primary optical outputs, having a relative delay therebetween, providing the inputs (3,4) to the optical phase detector (1; 30).

20. The frequency discriminator of claim 19, including input coupling means (41) for receiving the primary optical input (42) from the source of radiation (43).

21. The apparatus of claim 19 or 20 wherein the means for introducing a relative delay between the two primary optical outputs comprises two lengths of optical fibre (50,51) having different optical path lengths.

22. The apparatus of claim 19 or 20, wherein the means for introducing a relative delay between the two primary optical outputs comprises one length of optical fibre through which one of the primary optical outputs is transmitted.

23. The apparatus of claim 21 or 22 wherein the one or more length of optical fibre is any one of single mode optical fibre, polarisation maintaining optical fibre, temperature stable single mode optical fibre or temperature stable polarisation maintaining optical fibre.

24. A sensor comprising the apparatus (60) of any of claims 19-23 and including the optical phase detector (30) of claim 4.

25. The sensor of claim 24, wherein the relative optical delay between the two primary optical outputs is substantially zero.

26. The sensor of claim 24 or 25 for measuring any one of a variation in temperature, pressure or strain applied to an optical fibre (50) forming part of the sensor.

27. A laser stabilisation apparatus (70) for stabilising the output (42) from a laser (43) having a frequency, the laser stabilisation apparatus comprising,

a frequency discriminator apparatus (60) comprising input means (41) for receiving a primary optical input (42) from the laser (43) and for producing two primary optical outputs (52, 53), means (50,51) for introducing a relative delay between the two primary optical outputs (52, 53) and an optical phase detector (1:30), wherein the optical phase detector (1; 30) comprises means (2) for receiving the two optical inputs (52, 53) and producing two combined optical outputs (11,12), detection means (32) for detecting the intensity of the two combined optical outputs (11; 12) and converting the intensity of each of the

combined optical outputs (11,12) into an electrical signal; and means (6) for measuring the difference between the two electrical signals and generating an output difference signal (20),

the laser stabilisation apparatus further comprising feedback means (72, 74) for feeding back the output difference signal (20) from the optical phase detector (1; 30) of the frequency discriminator (60) to the laser (43).

28. The laser stabilisation apparatus (70) of claim 27 comprising one or more additional frequency discriminator apparatus (60) as in claim 19, each frequency discriminator apparatus having corresponding feedback means (72, 74) for feeding back the electrical output from the associated optical phase detector (1; 30) to the laser (43).

29. The laser stabilisation apparatus (70) of claim 28, wherein the outputs from the optical phase detectors (1:30) of the different frequency discriminators feed back to different control points on the laser (43).

30. The laser stabilisation apparatus (70) of any of claims 27-29, wherein the optical phase detector (30) includes a voltage-controlled electro-optic phase modulator (35; 80) for modulating the phase of one optical input to the optical phase detector (30), the electro-optic phase modulator (35; 80) having a substantially linear response.

31. The laser stabilisation apparatus (70) of any of claims 27-29, including a differential amplifier (82), the output from the optical phase detector (1:30) being fed back to an input of the differential amplifier (82), the output from the differential amplifier (82) being fed back to the laser.

32. The laser stabilisation apparatus (70) of any of claims 27-31, wherein the optical phase detector (1; 30) forming part of the laser stabilisation apparatus

comprises coupling means (2) for receiving the two optical inputs (3,4) and producing the two combined optical outputs (11,12).

33. An optical frequency synthesizer comprising;

the laser stabilisation apparatus (70) of claim 27 for stabilising an output from a laser, and

means (80;82) for varying the frequency of the laser output.

34. The optical frequency synthesizer of claim 33, including two optical fibres (50,51) for introducing a relative delay between the two primary optical outputs (52, 53), the two optical fibres having different optical path lengths.

35. The optical frequency synthesizer of claim 34, comprising an electro-optic phase modulator (80) arranged in the path of one of the lengths of optical fibres (50,51), whereby application of a SAWTOOTH-like voltage waveform to the electro-optic phase modulator (80; 35) gives rise to a variation of the frequency of the laser output.

36. The optical frequency synthesizer of claim 35 and further comprising a voltage source, providing a SAWTOOTH-like voltage waveform, for applying a voltage to the electro-optic phase modulator (80; 35).

37. The optical frequency synthesizer of claim 33, comprising a differential amplifier (82), the output from the optical phase detector (1:30) being fed back to an input of the differential amplifier (82), the output from the differential amplifier being fed back to the laser.

38. The optical frequency synthesizer of claims 33, wherein the optical phase detector (30) includes an electro-optic phase modulator (35; 80).

39. An optical vector voltmeter (90), for comparing an input laser signal (92) and a reference signal (94) comprising;

the optical phase detector (30) of claim 4 or 5, and

a photodetector (96) for receiving the input laser signal (92) and for generating an output signal dependent on the amplitude of the input laser signal (92),

the output from the electro-optic phase modulator (35) providing a measure of the phase difference between the reference signal (94) and the input laser signal (92).

40. An optical network analyser for measuring the transmitted or reflected amplitude and phase of a system (110) at a plurality of frequencies comprising;

an optical frequency synthesizer for generating a reference signal (76) at a plurality of frequencies, and

the optical vector voltmeter (90) of claim 39, for receiving as inputs the reference signal (76) and the signal transmitted or reflected by the system (110).

41. The optical network analyser of claim 40, wherein the optical frequency synthesizer is as claimed in any of claims 33-38.

42. A method of stabilising the output (42) from a laser (43) having a frequency comprising the steps of;

providing a frequency discriminator apparatus (60) comprising input means (41),

inputting a primary optical input (42) from the laser (43) to the input coupling means (41) and producing two primary optical outputs (52, 53),

introducing a relative delay between the two primary optical outputs (52, 53),

inputting the two primary optical outputs to an optical phase detector (1; 30), comprising coupling means (2) for receiving the two optical inputs (3,4) and producing two combined optical outputs (11,12),

detecting the intensity of the two combined optical outputs (11,12);

converting the intensity of each of the combined optical outputs (11,12) into an electrical signal,

measuring the difference between the two electrical signals and generating an output difference signal (20), and

feeding back the output difference signal (20) from the optical phase detector (1) of the frequency discriminator (60) to the laser (43).